REMARKS

This Amendment is submitted in response to the Office Action mailed on September 30, 2005. Claims 1 - 23 are pending, with claims 5, 6, and 8 allowable if re-written, and the remaining claims rejected at present.

Claim 5 has been re-written in independent form, and a charge slip is enclosed for the fee for the added independent claim. Claims 6 and 8 depend from claim 5, and need not be re-written.

Claim 23 has been amended to correct an obvious typographical error.

SUMMARY OF MAJOR POINTS

Anticipation Rejection

Claim 23 states that a "marker" "becomes visible" when an element changes in size.

The cited reference shows a groove, which is **always visible**, which changes in size when wear occurs. That does not correspond to the claim language. If the groove is **always visible**, then it does not "become visible" upon the change in size.

Rejections Based on Kumagai

Applicants make the following points.

Basic point. As this Amendment explains later, a gas turbine

engine on a large transport aircraft can burn 36,000 pounds (that is, 18 tons) of fuel per hour. That corresponds to **TEN POUNDS** per second. Thus, the flame in the combustor of such an engine resembles a **GIGANTIC BLOW TORCH**, burning **TEN POUNDS OF FUEL PER SECOND**.

There is no reason to believe, and no rationale has been presented which shows, that the tiny auxiliary electrode of Kumagai's automotive spark plug (explained later) could have any effect whatsoever on that flame. Thus, there is no reason to combine Kumagai's device with a gas turbine engine.

Further, Kumagai states that his auxiliary electrode serves to draw fuel into the gap of a spark plug, so that, when the plug fires, some special type of combustion will occur. But that type of operation has no relevance whatsoever to a gas turbine engine.

In a gas turbine engine, combustion is **constant** (except during a flame-out, which is rare, and represents non-normal operation).

However, in Kumagai's engine, combustion is **not constant**.

-- There is no combustion when the fuel is drawn into the cylinder,

and

-- There is no combustion when his auxiliary electrode draws fuel into the spark gap.

Thus, Kumagai's teachings have no relevance whatever to a gas turbine engine: in a gas turbine engine, during ordinary operation,

there is no time when the flame is absent. Thus, it is **impossible** to use Kumagai's auxiliary electrode to draw fuel into the gap between the electrodes of a spark plug. The reason is that the fuel will be ignited by the flame before it gets there.

Kumagai simply cannot be applied to a gas turbine engine.

Further still, for many of the claims, even if Kumagai's spark plug is inserted into a gas turbine engine, the claims are not attained until, as a minimum, a certain amount of erosion occurs in Kumagai's device. But it was just explained that Kumagai's device would never be put into a gas turbine engine in the first place, because it (1) would have no effect, and (2) would not operate according to Kumagai's teachings.

Additional points are the following.

Point One. The Kumagai reference is being modified in **direct contradiction** to its express teachings.

-- Kumagai states that his second electrode should **remain insulated**. The PTO removes the insulation.

-- Kumagai states that the electric field produced by the second electrode should be

1) "uniform" (in space)

and

2) "always" present "at the spark gap"

(ie, constant in time).

The PTO's modification makes the electric field

1) non-uniform in space

and

2) sporadic in time.

That is in direct contradiction to Kumagai's teachings.

Two. The PTO asserts that it is "inherent" that the insulator in Kumagai's spark plug will erode, and the PTO relies partly on Applicants' statements that erosion occurs in igniters in gas turbine engines.

However, the PTO's assertion ignores the fact that Applicants also state that the electrodes erode in a gas turbine engine too. (See Specification, paragraph 41, et seq.)

Further, as to Kumagai, everybody knows that the electrodes in automotive spark plugs erode first. The erosion eventually makes the spark gap so large that the spark cannot jump across it, and the spark plug stops firing. (See APPENDIX A, discussed in Point Four, below.) When that happens, no erosion of the insulator can continue (because spark has terminated), even if erosion of the insulator occurred initially.

Thus, for the PTO's assertion to be persuasive, it must show that the insulator in an automotive spark plug erodes faster than do the electrodes, or show some other mechanism by which the

second, buried, electrode in Kumagai becomes exposed. That has not been done.

Three. This continues Point Two.

The mechanism of plasma generation in a gas turbine engine is fundamentally different from that of an automotive spark plug. In a gas turbine engine, the plasma brushes along the insulator, in travelling between electrodes. This contact erodes the insulator.

There is no corresponding brushing/contact in an automotive spark plug.

This is consistent with the fact that erosion of the insulator in an automotive spark plug is not ordinarily observed.

Four. APPENDIX A, attached hereto, was found on the web site

www.spark-plugs.co.uk/pages/technical/diagnosis.htm

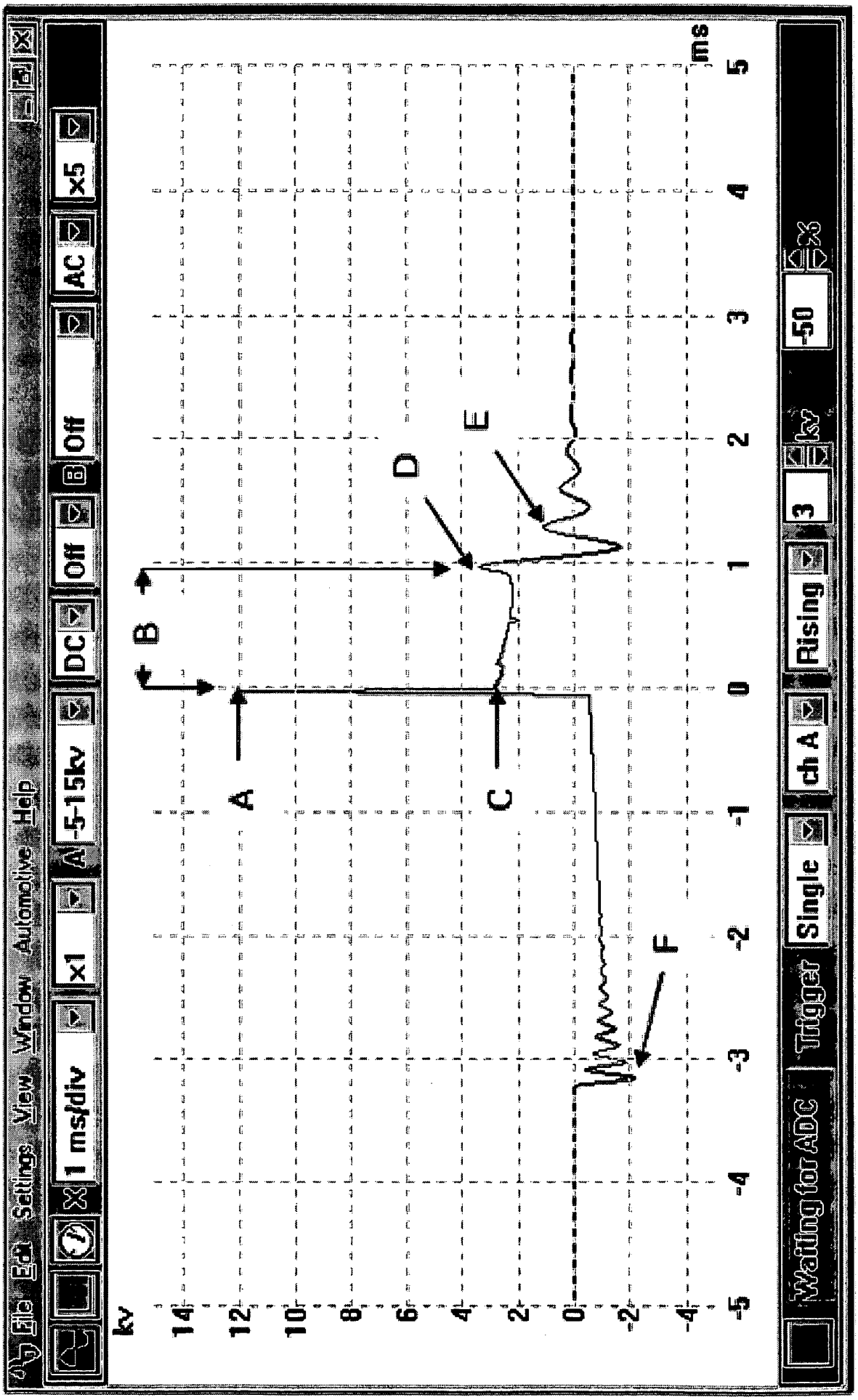
which was reached by doing a Google search on the query "spark plug diagnosis."

APPENDIX A illustrates photographs of various problems which occur in automotive spark plugs. Significantly, erosion of the insulator is not one of the problems. Also significantly, erosion of the **electrodes IS LISTED** as a problem, in at least two situations.

Therefore, Applicants submit that the prior art, as represented in APPENDIX A, teaches that electrodes in automotive spark plugs **do erode**, but the insulator **does not**. Therefore, the prior art teaches that the situation postulated by the PTO never occurs in normal operation of Kumagai.

Five. Even if the insulation erodes in Kumagai, as the PTO postulates, no spark will be generated by that electrode.

The following page illustrates a plot of the voltage



developed across the "secondary" of the ignition coil in an automobile. This plot was obtained from the web site

www.picotech.com/auto/tutorials/primary-vs-secondary.html

Point A in the plot represents the voltage applied to the spark plug. How this voltage is generated must be understood.

First, the "points" close, creating in the "primary" (1) a current, and (2) an accompanying magnetic field. Then, the "points" open, causing the current to terminate, and the magnetic field to collapse. This collapse creates the voltage at point A in the plot, in the "secondary," about 12,000 volts.

The voltage causes breakdown of the air-fuel mixture between the electrodes of the spark plug. A spark thus occurs, and persists for duration B in the plot. At point D, the distributor dis-connects the secondary from the park plug.

Applicants point out that no mirror-image negative swing in voltage occurs, which mirrors the rise to point A. Instead, an RLC type decay occurs, following the disconnection, at point D.

The preceding events have the following significance to Kumagai.

When the voltage of point A in the plot above is applied to Kumagai, the diode 38 in Kumagai's Figure 3 is reverse-biased, and is thus an open circuit. Thus, even if the insulation around

electrode 36 has eroded away, no high voltage is ever applied to that electrode which can cause a spark.

In view of this, it could be argued that, if a sufficiently large **NEGATIVE** voltage is applied to line 37 in Kumagai's Figure 3, then a spark could jump from the housing 10 to the electrode 36. However, no such **negative** voltage occurs, as the plot above indicates from point D onward. There is no negative mirror-voltage to point A.

Therefore, no sufficient potential difference ever occurs between electrode 36 and any other electrode in Kumagai, to cause a spark.

The PTO's proposed spark-following-insulator-erosion never arises.

Six. As explained in Point Five, no sufficiently high positive voltage is applied to electrode 36 in Kumagai's Figure 3. If a sufficient negative voltage (which never occurs) is to be applied, it must occur after point D in the plot.

But that is too late, from the perspective of ignition timing. At 3600 rpm, corresponding to 60 rev/sec, the crankshaft turns 360 x 60 degrees, or 3600 degrees, every second. That is 3.6 degrees per millisecond.

The delay B in the plot represents one millisecond, and thus 3.6 degrees. Any spark occurring after point D is at least 3.6

degrees too late.

Thus, even if electrode 36 in Kumagai's Figure 3 erodes, and produces spark when a negative voltage is applied, the timing of the spark is improper. The engine will not run properly, and the spark plug will be replaced.

The effect of faulty timing is explained at the web site

www.centuryperformance.com/timing.asp

Seven. The PTO asserts that some erosion, no matter how small, necessarily occurs in an automotive spark plug and, thus, eventually, the buried electrode in Kumagai's spark plug will become exposed.

However, if that event occurs in the future, it cannot be used as prior art.

To be used as prior art, that event must be shown to occur at one of the times specified in section 102, such as one year prior to Applicants' filing date, etc. That showing has not been made.

If that event is treated as being inherently taught in Kumagai, then Applicants point to MPEP § 2112, which states:

> EXAMINER MUST PROVIDE RATIONALE OR EVIDENCE TENDING TO SHOW INHERENCY.
>
> In relying upon the theory of inherency, the examiner must provide a **basis in fact and/or technical reasoning** to reasonably support the

> determination that the allegedly inherent characteristic necessarily flows from the teaching of the applied prior art.

No such basis in fact or technical reasoning have been given.

Eight. The rationale for combining Kumagai and Rothenbuhler is self-contradictory.

The Office Action, page 6, asserts that Kumagai is relevant to gas turbine engines, because Kumagai seeks a goal of "lean burning," which gas turbine engines supposedly also seek.

However, the Office Action then modifies Kumagai, and eliminates the supposed "lean burning" feature.

That is, the Office Action exposes Kumagai's electrode to air, which eliminates the electric field which Kumagai supposedly uses to attain the "lean burning." (This elimination is explained herein.)

Thus, the PTO's modification eliminates the feature of Kumagai which supposedly produces the goal (lean burning), which was the motivation for combining the references in the first place.

The rejection is self-contradictory.

Further, the assertion that gas turbine engines seek "lean burning" cannot be used, because the assertion is unsubstantiated.

In addition, this assertion contradicts the following fact. It is well known that, in combustion, the maximum amount of heat

is produced when the reaction is "stoichiometric." That is, when the correct number of oxygen molecules are supplied to fully react with the fuel.

For example, if hydrogen were burned, the reaction would be

$$2\ H_2 + O_2 \text{ -->> } 2\ H_2O$$

One part oxygen are required for every two parts of hydrogen, for stoichiometric burning.

A gas turbine engine wants to produce the maximum amount of heat because, in essence, that heat is used to pressurize air, which is then shot through a nozzle, or through a turbine, or both. Maximum heat produces maximum pressure, and maximum pressure is desired.

If "lean burning" is introduced, then the amount of oxygen is insufficient. The reaction is no longer stoichiometric. Maximal heat is not produced.

Given that, Applicants request a justification of the assertion that gas turbine engines seek "lean burning."

Nine. Kumagai is plainly inoperative. Kumagai asserts that his electric field will draw fuel particles into the spark gap of a spark plug. (Column 1, lines 29 - 31.) But it is common knowledge that an electric field can only move **charged** particles. At no place does Kumagai explain how he applies a charge to the fuel particles.

Thus, his electric field will not move his fuel particles, as he asserts.

Also, Kumagai asserts that his invention promotes "lean burning." (Column 1, line 30.) However, if his (inoperative) method actually succeeds, then he draws fuel into the spark gap. That makes the mixture **richer**, not leaner: more fuel is drawn into the gap of the spark plug. More fuel represents a **richer** mixture, not a leaner mixture.

And independent of that, it may be assumed that, whether his invention is used or not in a given engine, all fuel in the cylinder will be burned. [Why would any fuel not be burned ? The unburned fuel represents (1) a waste of money, and also (2) air pollution by way of injection of fuel vapor into the atmosphere.]

Kumagai's invention, if it works at all, only moves fuel from one location to another. But the fuel is still within the cylinder, in the presence of atmospheric oxygen, and it still burns.

How does mere movement of the fuel from one place to another make the burning "leaner" ?

Inoperative references cannot anticipate. For a reference to be anticipatory under section 102, the reference must be enabling. (See Patents by D. Chisum, sections 3.06(1)(a) and 304(1).)

Ten. A video of a gas turbine igniter in operation is

available at

www.unisonindustries.com/corporate/history/innovation.html

This video clearly shows that such an igniter produces an enormous plasma, compared with an automotive spark plug, which produces a plasma the size of a human hair. That hair-sized plasma extends across the spark gap, which is, for example, 0.040 inch long.

One reason why the gas turbine igniter produces such a large plasma is that the amount of fuel which must be ignited is vastly larger than the amount in a single charge in a cylinder in an automotive engine. Another reason is that kerosene (ie, jet fuel) is simply more difficult to ignite than gasoline.

Therefore, Applicants submit that the automotive spark plug references are non-analogous art. Gas turbine engine designers would not use automotive spark plugs in a gas turbine engine.

Eleven. In theory, an automotive spark plug could be used in a gas turbine engine. However, in practice, it would not be, because it does not produce sufficient heat to be reliable. This fact was confirmed with an engineer, identified herein, having extensive experience in designing gas turbine engines. The undersigned attorney offers to submit an affidavit on this point,

if requested.

Comment

Not all points made herein are elaborated below. Some are considered self-explanatory.

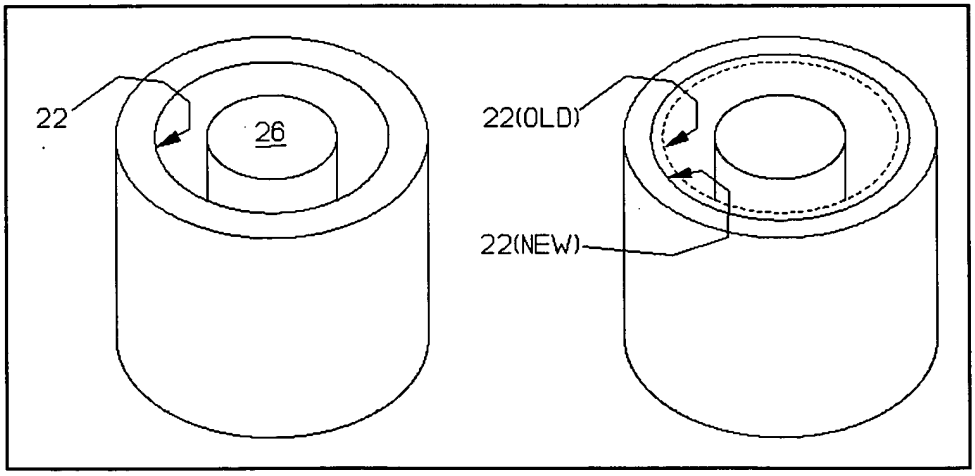
END MAJOR POINTS

CLAIM 23

Claim 23 was rejected on grounds of anticipation, based on Rothenbuhler.

Rothenbuhler Reference

Sketches 1 and 2, below, are simplified illustrations of relevant parts of Rothenbuhler.

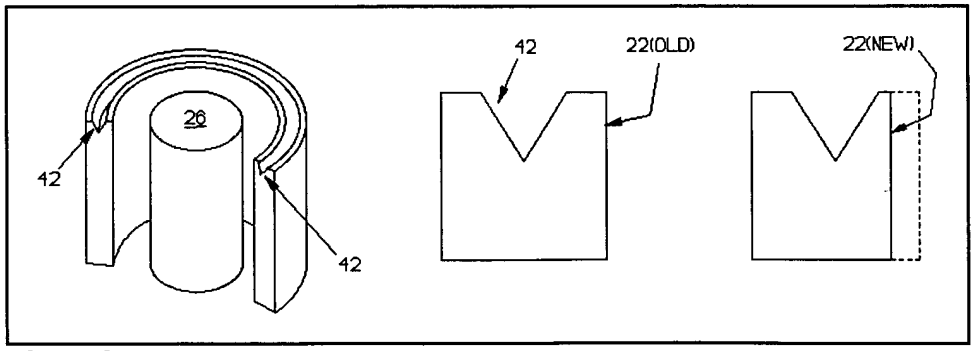


SKETCH 1

In Sketch 1, left side, a positive voltage is applied to electrode 26, causing a spark (not shown) to jump to the edge 22 of a negative electrode. Over time, edge 22 erodes, as shown on the right side of the Sketch, wherein the original position of edge 22 is indicated by phantom 22(OLD), and 22(NEW) indicates the new position of the edge 22.

Rothenbuhler states that a technician uses a measuring gauge to detect the new position of edge 22, and determine whether the device is still usable.

Rothenbuhler's invention is shown in Sketch 2, left side. He forms an annular groove 42 in the negative electrode. As edge 22 erodes, as indicated on the right side of the Sketch, it approaches the groove 42. The technician can visually estimate when the edge 22 becomes sufficiently close to the groove 42. No gauge is necessary.



Sketch 2

Claim 23

Claim 23 recites:

23. An igniter for a gas turbine engine, comprising:

a) ~~a first electrode~~ an element which changes in size during operation; and

b) a marker **which becomes visible** when a predetermined change in size occurs.

Applicants point to the **highlighted** phrase: claim 23 states that a marker "becomes visible" when a certain event occurs. One example of subject matter supporting this phrase is found in the Specification, paragraphs 44 - 53, wherein erosion of the igniter causes auxiliary electrode 72 to become visible. Prior to sufficient erosion, electrode 72 was not visible. After the erosion occurs, electrode 72 becomes visible.

That operation is not found in Rothenbuhler. His groove 42 is **always visible**. Restated, there is no "marker" "which **becomes visible**" as claimed.

Consequently, Applicants request, under 37 CFR §§ 1.104(c)(2) and 35 U.S.C. § 132, that the PTO specifically identify the claimed "marker" in Rothenbuhler.

Applicants offer to add language to claim 23 to emphasize that the "marker," prior to the "predetermined change in size" is not visible, if the Examiner so requests. However, such a recitation is considered non-necessary, because it is clearly contained in the

language "becomes visible."

If something "becomes visible," then prior to the "becoming," it was not visible.

Applicants point out that claim 23 was not amended to overcome the reference. Even without the amendment, claim 23 does not read on the reference.

CLAIMS 1 - 3, 9 - 12, 14, 15, 18, 19 - 21, and 23

These claims were rejected on grounds of anticipation, based on Kumagai.

General Response

Applicants submit that the rejection is fraught with numerous problems, discussed below. However, perhaps the most serious are the following four problems.

Problem 1

The first problem is that the PTO asserts that, during operation, the insulator 60 in Kumagai's Figure 11 will erode away, exposing electrode 57, thereby showing the claims in question.

Applicants point out that Kumagai teaches directly against this. As explained below, Kumagai expressly states that the electrode in question should remain covered with insulation.

Restated, the PTO is interpreting a reference in direct

contradiction to the reference's teachings.

Problem 2

Applicants point out that the PTO is ignoring important statements made in the Specification.

The Specification states that erosion of the insulator occurs in the igniter of a gas turbine engine. The Specification, paragraph 41 et seq., also states that erosion of the **electrodes** in the igniter occurs.

The PTO uses the first statements, but ignores the second statements. The PTO asserts that erosion occurs in Kumagai's insulator. But the PTO ignores the fact that Kumagai's electrodes erode too.

Any auto mechanic will tell you that the electrodes in Kumagai's spark plug will erode first. Once they do, sparking terminates, and no further erosion occurs. APPENDIX A supports this proposition.

Given that, the PTO must, under the MPEP section on inherency, cited herein, provide technical reasoning as to why Kumagai's insulation will erode and expose his concealed electrode.

Problem 3

The PTO's proposed mode of operation of Kumagai is directly contrary to Kumagai's stated goal.

Kumagai, column 6, line 10 et seq., states that "a **uniform** electric field" is "**ALWAYS**" provided "at or about the spark gap" by his extra electrode. Thus, he states that his electric field is

1) uniform in space

and

2) constant in time.

If the extra electrode 57 in Kumagai's Figure 11 (designed to attract fuel particles) becomes involved in generating spark (because of erosion), then

-- any electric field will not be uniform

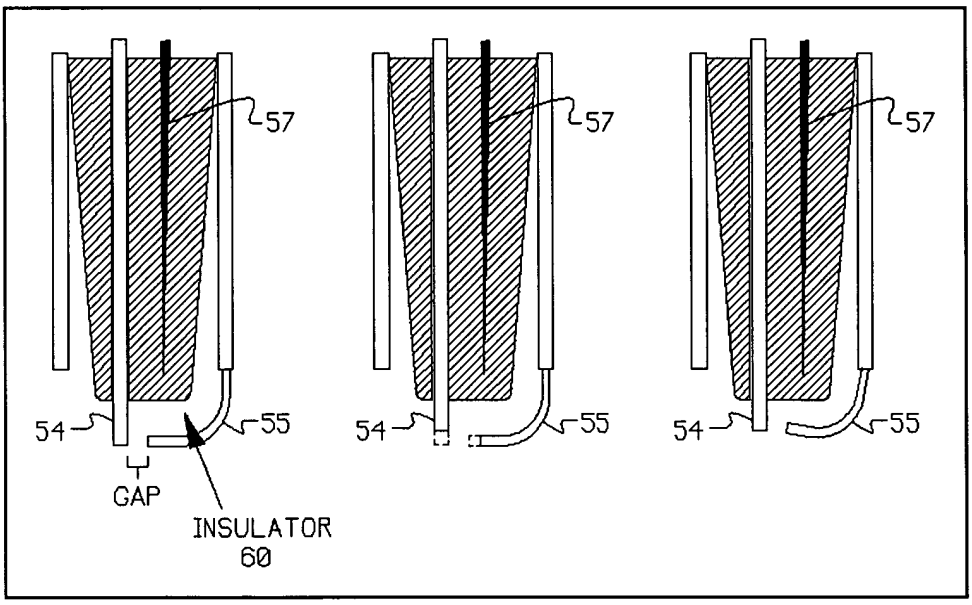
-- any electric field will be intermittent.

Restated, the new electric field is **neither** "uniform" in space nor "always provided" over time, contrary to Kumagai's teachings.

The PTO's proposed mode of operation will be contrary to Kumagai's stated teachings.

Problem 4

The fourth problem is illustrated by Sketch 3 below, which is a rendition of part of Kumagai's Figure 11.



Sketch 3

The spark plug begins life at the left side of Sketch 3. Then, parts of electrodes 54 and 55 erode away, as indicated by the dashed regions in the central image. When erosion becomes sufficiently great, sparking stops, because the applied voltage is insufficient to jump the gap between the electrodes 54 and 55.

The solution is to close the gap, as by bending one, or both, electrodes, as shown at the right side of the Sketch. However, eventually, electrode 55 will become so short that the gap can no longer be closed.

Here is the problem. The PTO must show that the supposed erosion of the insulator occurs prior to this event. That has not been done.

Restated, even if erosion of the insulator occurs (which Applicants dispute), no further erosion will occur when electrode 55 becomes so short that it cannot be bent to re-close the gap. The PTO must show that the erosion of the insulator occurs prior to that time.

That has not been done.

Therefore, the PTO has not shown that the claimed erosion occurs in the reference. MPEP § 2131 states:

> A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference.

Specific Responses: Claim 1

Claim 1 recites:

> 1. Method of operating a fuel igniter in an engine, comprising:
>
> a) generating a first plasma near a first end of a first electrode;
>
> b) maintaining a second electrode having a second end;
>
> c) initially surrounding the second end with a solid insulation; and
>
> d) eroding the solid insulation, to expose the second end, and then generating a second plasma between the first and second electrodes.

Applicants respectfully point out several apparent problems in the PTO's interpretation of Kumagai.

Point 1

The Office Action proposes a mode of operation of Kumagai which is directly contrary to Kumagai's express teaching.

The Office Action relies on electrode 57 in Kumagai's Figure 11 to show the claimed "second electrode." The Office Action asserts that the insulator 60 will inherently erode away, thus exposing the electrode 57.

However, Kumagai expressly states that the electrode 57 must be kept insulated from ambient gases. In his Background, he explains that the comparable electrode 90 in his prior art Figure 1 fails to work properly, because of exposure to gases. And he explains why.

He states that, during the intake stroke of the piston, pressure drops within the cylinder, causing "glow discharge," because the electrode 90 ionizes the low-pressure gases. This reduces the voltage on the electrode 90. (Column 1, lines 18 - 26.)

Since a high voltage on electrode 90 is desired, to create an electric field which will attract fuel particles, the drop in voltage is not desired. Therefore, Kumagai insulates his electrode, as in his Figure 3.

Further, in his claim (column 7, lines 14 - 16) he states that the electrode in question is isolated from the atmosphere in the combustion chamber.

Consequently, the PTO, in asserting that the insulator 60 in Kumagai's Figure 11 will erode away, is contradicting Kumagai's own teachings.

If, in fact, such erosion would occur, then Kumagai's clear teaching is that the entire spark plug should be replaced. The reason is that the glow discharge occurring because of the erosion of the insulator will now render his invention useless.

Point 2

In asserting that Kumagai's insulator erodes away, the PTO relies on the doctrine of Inherency. MPEP § 2112 states:

> EXAMINER MUST PROVIDE RATIONALE OR EVIDENCE TENDING TO SHOW INHERENCY.
>
> In relying upon the theory of inherency, the examiner must provide a **basis in fact and/or technical reasoning** to reasonably support the determination that the allegedly inherent characteristic necessarily flows from the teaching of the applied prior art.

Applicants point out that no "basis in fact" nor "technical reasoning" have been given, as required by this MPEP section. It is requested that such "basis" and "reasoning" be provided.

One reason for this request is that Kumagai is plainly discussing spark plugs used in automotive engines. The undersigned attorney has performed maintenance on numerous internal combustion gasoline engines, including automotive-, motorcycle-, and lawnmower-engines, as well as single-cylinder general-purpose gasoline engines. He can recall no instance of finding erosion in the insulator of a spark plug. In all cases, the insulator, when cleaned of any soot present, was shiny and glassy, with no evidence of erosion.

Further, a copy of a diagnostic chart is attached as APPENDIX A. This chart illustrates various types of problems which can occur in automotive spark plugs. It is considered significant that nowhere does the chart indicate erosion of the insulator as a problem.

This chart is therefore taken as evidence that erosion of an insulator does not normally occur in spark plugs of the type described in Kumagai. Therefore, a request for an explanation of why erosion is "inherent" seems warranted.

Point 3

The PTO is proposing a mode of operation which defeats the goal of Kumagai. Kumagai uses his electrode 57 to maintain an electric field which will attract fuel particles. If electrode 57 becomes exposed to air, the "glow discharge" described above will

occur, thereby reducing, or eliminating, the electric field.

Elementary electromagnetic field theory explains why the field is reduced. Initially, a field is caused by the electrode. That field pulls electrons from nuclei, in an ionization process. Now dipoles exist: pairs of separated particles are present, which are charged.

By convention, an electric field points in the direction which a positive charge will move. If the field in question points left-to-right, then positive charges are drawn to the right, and negative charges are drawn to the left.

This movement (of positive charges to the right, and negative charges to the left) causes each pair of positive-negative charges to create its own small field, between themselves. In this example, that field is pointing to the **left**. This leftward-pointing field, when added vectorially to the initial field, **reduces** the initial field.

This is a simple explanation of why Kumagai's "glow discharge" reduces the applied field. This type of explanation can be found in many college physics texts in a section which explains why a dielectric in a capacitor increases the capacitance. Polarization of the dielectric creates a second electric field, opposite to the applied field, which reduces the applied field when vectorially added to the applied field.

MPEP § 2143.01 prohibits the operation of Kumagai proposed by

the PTO:

> THE PROPOSED MODIFICATION CANNOT RENDER THE PRIOR ART UNSATISFACTORY FOR ITS INTENDED PURPOSE.
> . . .
> THE PROPOSED MODIFICATION CANNOT CHANGE THE PRINCIPLE OF OPERATION OF A REFERENCE.

The PTO is proposing exposure of Kumagai's electrode, to generate spark. Kumagai expressly states that such exposure reduces his electric field, which he wishes to avoid.

Point 5

This Point 5 is simple.

Kumagai states that he wants to maintain insulation around his electrode.

It is well known that insulation is available for automotive spark plugs which does not erode.

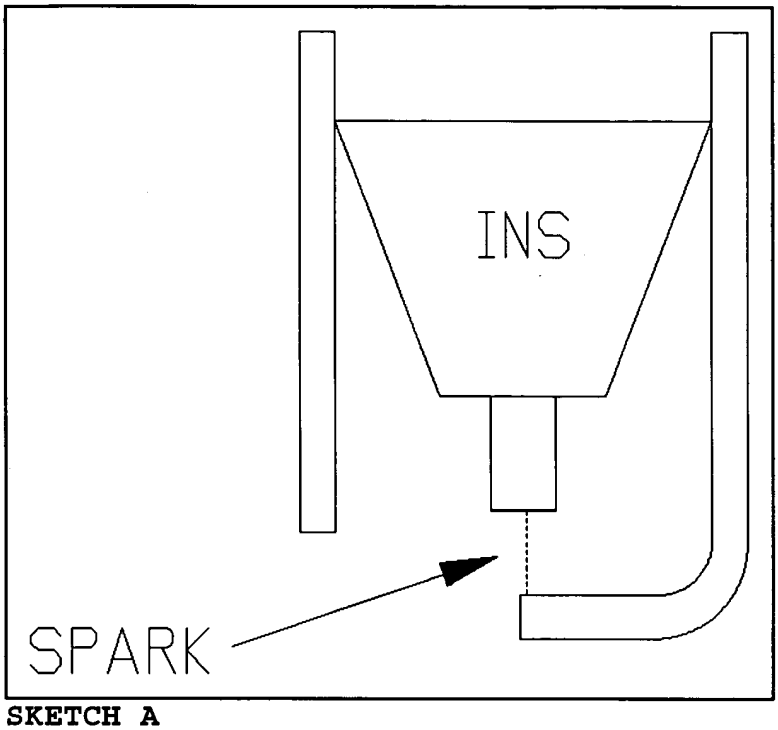
Therefore, it is reasonable to assume that Kumagai utilized this non-eroding insulation, and that his insulator does not erode to any significant extent.

Point 6

The Office Action relies on Applicants' assertion that erosion occurs in a gas turbine engine, to support its proposition that erosion occurs in Kumagai. However, a gas turbine engine provides

a completely different environment than does Kumagai's automotive engine.

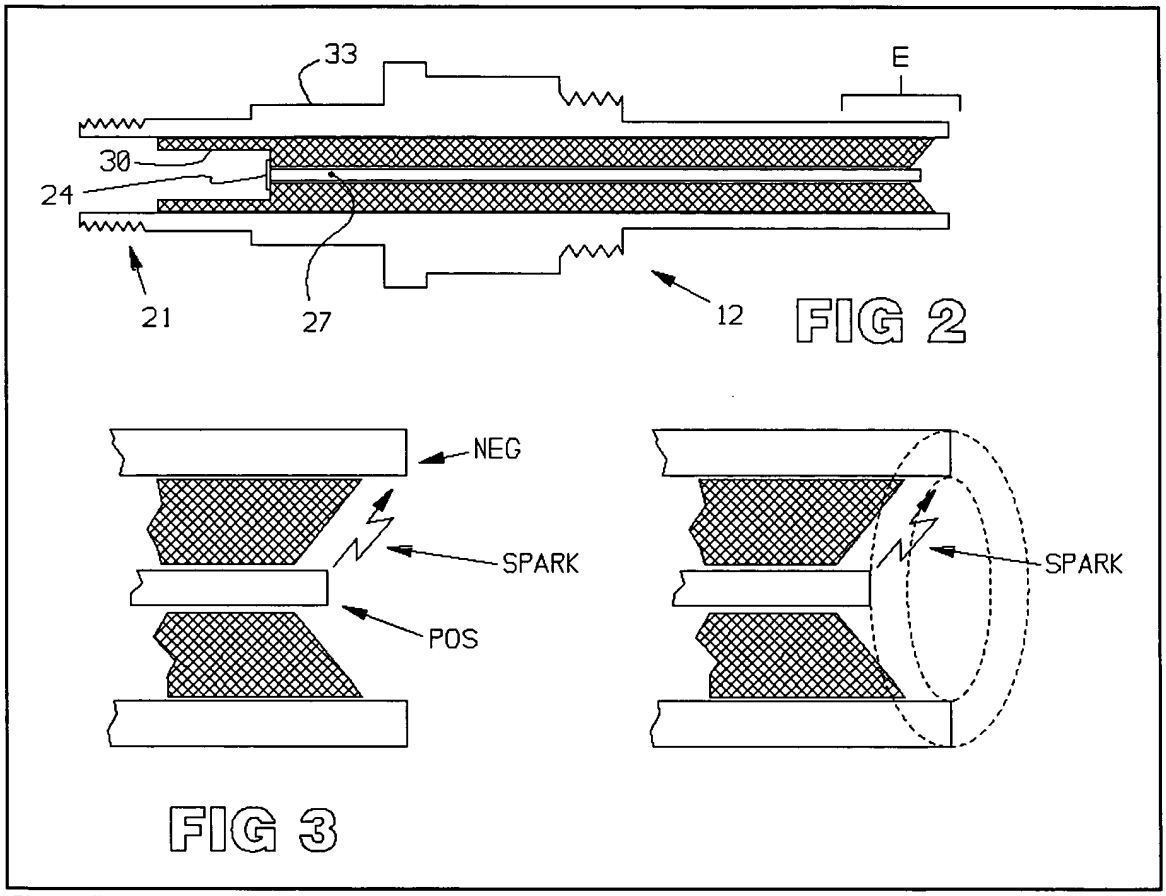
Sketch A, below, illustrates a generic automotive spark plug.



SKETCH A

The undersigned attorney has observed demonstrations of automotive spark plugs, and points out that the actual spark, in air, is blue in color, and about the size of a human hair, spanning between the electrodes. The spark, in spanning between the electrodes, is separated from the insulator INS. That is, the spark jumps **directly** between the electrodes, and does not touch the insulator.

In contrast, the "spark" in a gas turbine igniter is actually a plume of plasma, or flame. Sketch B, below, is based on Applicants' Figures 2 and 3 in the Specification. Figure 2 illustrates an igniter, and Figure 3 illustrates the end of the igniter.



SKETCH B

Applicants point out several things about such an igniter, and the plasma it creates.

One, the negative electrode is actually a cylinder, as indicated at the right side of Sketch B. Thus, the spark can jump to any point on that cylinder.

In actual fact, the observed behavior is the following. The spark initially jumps to a single point on the cylinder repeatedly. That erodes material from that point, thereby increasing the distance to that point, and causing the spark to jump to another, closer, point, and the process repeats.

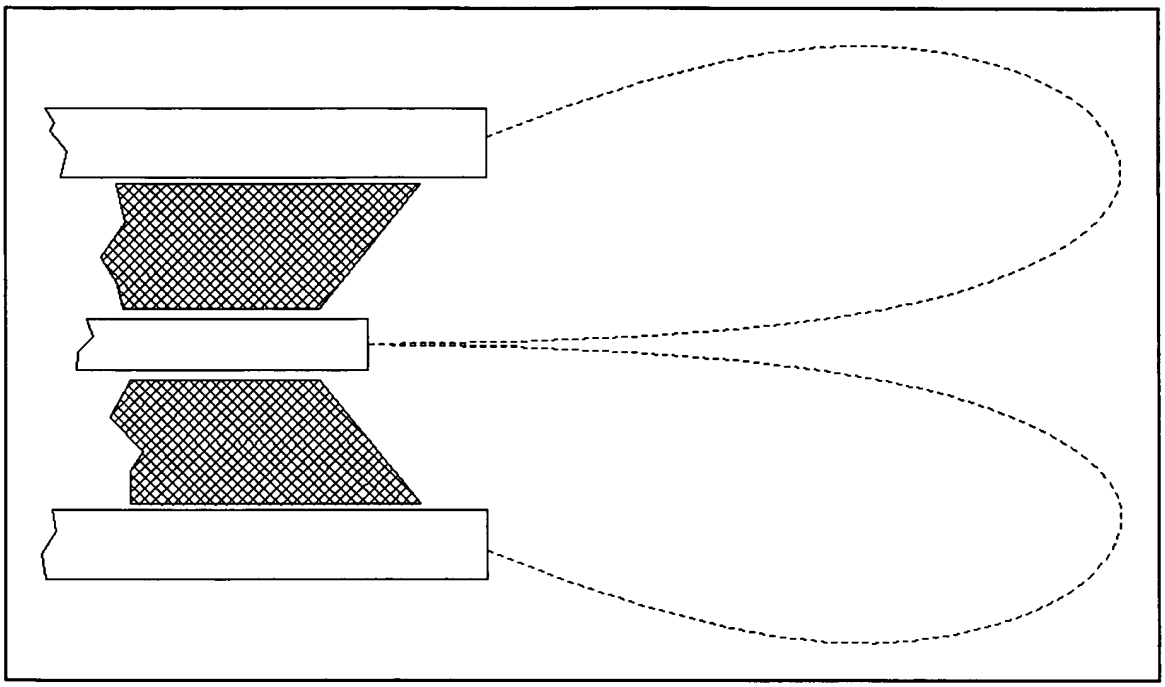
The succession of sparks brushes against the insulator, eroding the insulator. In contrast, the spark of Kumagai's automotive spark plug does not touch the insulator, and does not erode it.

Two, the intensity of the spark in the igniter is much, much greater than that in an automotive spark plug. A video of a spark-plume in a gas turbine igniter is available at

www.unisonindustries.com/corporate/history/innovation.html

The menu item labeled "plume" leads to the video.

That video indicates that the "spark" in a gas turbine engine is actually a plume of plasma, as indicated in Sketch C, below.



SKETCH B

This plume is vastly larger than the spark produced by the automotive spark plug of Sketch A, above.

Also, in a gas turbine engine, the gap across which the spark, or plasma, must jump is five to ten times larger than that of an automotive spark plug. Automotive spark plugs may have a gap of 0.035 inch. An igniter can have a gap of 0.25 to 0.5 inch.

Thus, the voltage used in the igniter is five to ten times larger, explaining the larger plume shown in the video, compared to the hair-like spark in an automotive spark plug.

Therefore,

-- the plasma-plume of a gas turbine igniter is much larger than the spark of an automotive spark plug;

-- the plume is adjacent the insulator, which is not the case of an automotive spark plug; and

-- the voltage in the igniter is five to ten times, or more, that of an automotive spark plug;

These three factors help to explain the observation that the insulators in automotive spark plugs do not erode, while those in gas turbine engines do.

Point 7

The PTO's proposed mode of operation of Kumagai is directly contrary to Kumagai's stated goal.

Kumagai, column 6, line 10 et seq., states that "a **uniform** electric field" is "**ALWAYS**" provided "at or about the spark gap" by his extra electrode.

If that extra electrode 57 in Kumagai's Figure 11 (designed to attract fuel particles) becomes involved in generating spark (because of erosion), then

-- any electric field will not be uniform

-- any electric field will be intermittent.

The PTO's proposed mode of operation will be contrary to Kumagai's stated teachings.

Point 8

If this situation shows anticipation, then this is a case of "accidental anticipation." "Accidental anticipations" are those which occur only under unusual circumstances, and do not constitute anticipations under section 102. (See Law of Patents, by D. Chisum, §§ 3.03 and 3.03(2).)

As explained above, the PTO proposes a mode of operation in Kumagai which Kumagai does not want, and which defeats Kumagai's intended purpose. Further, Kumagai does not state that he uses his spark plugs, once the condition proposed by the PTO arises. Kumagai would replace the spark plugs when this condition arises.

Therefore, Applicants submit that the supposed "anticipation" is an "accidental anticipation," which, by law, is not anticipation at all.

Point 9

As a technical matter, it is submitted that, long before the insulator 60 in Kumagai's Figure 11 erodes away, the positive and negative electrodes 54 and 55 will have eroded away. (See APPENDIX

A.) At that time, no further sparking will occur.

Since no further sparking will occur, no erosion of insulator 60 will occur.

Thus, the condition proposed by the PTO will never be attained. The spark plug becomes inoperative before the erosion of the insulator 60 occurs.

Point 10

Even if erosion of the insulator 60 does occur in Kumagai, no spark will jump to the electrode 57. The spark will jump the shortest distance, and that distance is between the positive electrode 54 and the negative electrode 55.

That is a matter of simply physics.

Thus, when the supposed erosion of Kumagai's electrode occurs, the now-exposed electrode will not become involved in generating a spark. The spark will jump the shortest distance, which is not to that electrode.

Point 11

It is axiomatic that, for Kumagai to **anticipate** claim 1, Kumagai must **infringe** claim 1. (See PATENTS, A Treatise on the Law of Patentability, Validity, and Infringement, by D. Chisum, section 3.02[1], entitled, "The Classic Infringement Test.")

But Kumagai expressly states that his electrode 57 should

remain covered with insulation. Thus, claim 1(d) is not found.

Kumagai does not infringe. Thus, he does not anticipate.

Point 12

For a reference to be anticipatory under section 102, the reference must be enabling. (See Patents by D. Chisum, sections 3.06(1)(a) and 304(1).)

The PTO asserts that, at some time between now and eternity,

-- Kumagai's insulator will erode away,

exposing electrode 57 in his Figure 11

and

-- that electrode 57 will then produce spark.

But Kumagai provides no enablement as to how this would be accomplished.

Kumagai is not enabling to attain the result the PTO postulates.

Point 13

The PTO is not applying prior art. Claim 1 can only be rejected on prior art.

The PTO is asserting that, at sometime prior to eternity, Kumagai's insulation will erode away. However, that is not prior art.

The PTO must show all of the elements of claim 1 at a time

specified by section 102 (more than one year prior to Applicants' filing date, prior to Applicants' date of invention, etc.)

The PTO has not shown that the supposed erosion will occur prior to the times specified by section 102. Instead, the PTO asserts that the supposed erosion will occur at an unspecified time in the **future**. That is insufficient under section 102.

Applicants thus ask: when does the erosion occur in Kumagai ? If it did not occur at a time specified in section 102, then the erosion cannot be used as prior art.

Claims 2, 3, 9 - 12, 15, 18

The preceding applies to the claims listed above.

Claim 14

Claim 14(c) has not been shown in Kumagai.

Claim 19

Claim 19 recites:

19. An igniter for a gas turbine engine, comprising:

a) first and second electrodes which

i) cooperate to generate a plasma; and

ii) wherein plasma generation is accompanied by a change which inhibits later plasma generation; and

b) a third electrode which

i) becomes available with said change; and

ii) cooperates with either the first or second electrode to generate a plasma.

Applicants point out the following problems in applying Kumagai to claim 19.

Problem 1

Claim 19(a) recites two electrodes, and a change "which inhibits later plasma generation." The Specification, paragraph 41 et seq., provides an example of such a change: erosion of the electrodes increases the gap between them, eventually causing the spark to terminate.

The only relevant electrodes in Kumagai's Figure 11 are

electrodes 54 and 55. The PTO asserts that the claimed "change" will be erosion of insulation in Kumagai. However, the PTO has not shown that this erosion causes spark to terminate in Kumagai. Thus, no change "which inhibits later plasma generation" has been shown.

Further, if the claimed "change" occurs, then the engine will operate poorly, the problem will be identified, and the faulty spark plug replaced. Claim 19(b) will never be attained.

Problem 2

The Office Action asserts that it is "inherent" that events of claim 19(b) will follow 19(a) in Kumagai.

However, the Office Action must be relying on the following types of erosion.

1) Erosion of insulator 60 in Kumagai's Figure 11.

2) Erosion of electrodes 54 and 55.

However, (1) does not produce claim 19(a), and (2) does not produce claim 19(b). Thus, in either case, claim 19 is not attained. This will be explained further.

The Office Action has shown no mechanism in Kumagai by which

-- electrodes 54 and 55 in his Figure 11 fail to produce spark,

and then

-- the third electrode 57 then cooperates with electrode 54 or 55 to produce a spark.

That is, the PTO asserts that erosion of the insulator 60 occurs. However, that will not prevent electrodes 54 and 55 from producing spark. Thus, when this type of erosion occurs, claim 19(a) is not found.

If erosion of electrodes 54 or 55 causes spark to disappear as in claim 19(a) (because the distance between the electrodes becomes too great for the coil voltage to break down the gases between the electrodes), that erosion does not expose electrode 57 in Kumagai's Figure 11. Claim 19(b) is not present.

Therefore,

-- If erosion of Kumagai's electrodes 54 and 55 occurs, spark may disappear as in claim 19(a), but claim 19(b) is not found;

-- Conversely, if erosion of Kumagai's insulator 60 occurs, that does not affect electrodes 54 and 55, so that claim 19(a) is not found.

In either case, one claim passage is missing. And no other types of erosion have been invoked in Kumagai by the PTO.

Problem 3

Applicants submit that, in view of the contradictions

identified in Problem 2, above, MPEP § 2112 requires a "basis in fact" or "technical reasoning" which explains why claim 19 is "inherent" in Kumagai.

Claim 20

Claim 20 recites:

> c) a third electrode which
>
> > i) is separated from the first electrode by an erodible shield; and
> >
> > ii) cooperates with the first electrode to generate a plasma when sufficient erosion of the shield occurs.

The "first electrode" must be electrode 54 in Kumagai's Figure 11. But Kumagai's electrode 57 is farther from electrode 54 than his ground electrode 55. Thus, there is no reason to believe that a spark will jump from electrode 54 to electrode 57, even if the latter becomes exposed.

And, as explained above, Kumagai is discussing automotive spark plugs. The insulators in them do not erode in ordinary use.

Further, claim 20 states that the claim elements are "comprised" of "an igniter for a gas turbine engine." Kumagai does not show such an "igniter."

Claim 21

Claim 21 states:

> 21. Igniter according to claim 20, wherein both the second and third electrodes cooperate with the first electrode to generate a plasma after predetermined erosion occurs.

Applicants point out that the PTO's interpretation of Kumagai with respect to claim 21 contradicts its interpretation with respect to claim 19.

Claim 19(a) states that the first and second electrodes fail to produce a plasma after a certain event.

Claim 20 states the opposite.

Kumagai cannot be interpreted to support two opposing propositions.

Claim 23

The "marker" which "becomes visible" when an "electrode" "changes in size" has not been shown in the reference.

Remaining Claims

The discussion above applies to the remaining claims in this group.

CLAIMS 1 - 3, 7, 9 - 12, 14, 15, 18, 19 - 21, and 23

These claims were rejected as obvious, based on (1) Kumagai,

(2) Rothenbuhler, and (3) admitted prior art. However, several problems exist in the rejection.

Problem 1

The rejection fails to show all claim elements in the references. MPEP § 2143.03 states:

> To establish prima facie obviousness . . . **all the claim limitations** must be taught or suggested by the prior art.

The erosion of insulation of the claims has not been shown.

The gas turbine engine of the claims has not been shown.

Also, several claims state that the second electrode surrounds the insulator. Two references are contradictory on this point, and the contradiction has not been resolved by the PTO.

Problem 2

The rejection is filled with unsupported, or incorrect, statements, including the following.

One. The rejection asserts that Kumagai's proposed lean burning occurs in gas turbine engines "due to emission requirements." However, Kumagai's engines operate on the Otto Cycle, which is sometimes characterized as constant-volume combustion, because much of the combustion occurs rapidly at the end of the compression stroke, before the piston moves appreciably,

and then the heated gases cause the expansion stroke of the piston.

In contrast, gas turbine engines operate on the Brayton Cycle, which is constant pressure (not constant volume) combustion.

Thus, at a minimum, since Kumagai utilizes a different thermodynamic cycle that does a gas turbine engine, the burden is on the PTO to show that Kumagai's teachings are relevant to the gas turbine engine's Brayton cycle. That has not been done.

Stated more simply: the PTO must show that Kumagai's goal of "lean burning" is relevant to a gas turbine engine.

Two. Even if Kumagai's proposal of "lean burning" is applicable to gas turbine engines, the PTO has not shown how Kumagai's electric field would operate in a gas turbine engine.

For example, as Applicants' Background of the Invention points out, the flame in a modern gas turbine engine is self-sustaining. The igniter is only used as a safety precaution, and operates sporadically.

It is incumbent on the PTO to show how this sporadic operation of Kumagai's electric field would draw fuel particles to the igniter, and what effect such drawing would accomplish.

Three. The PTO is comparing apples with oranges, part 1.

The amount of fuel involved in a gas turbine engine, compared to Kumagai's engines, is thousands of times greater. Thus, it is

highly doubtful that Kumagai's electric field could have any influence on the combustion process in a gas turbine engine. A simple numerical example will illustrate.

Assume, in Kumagai, a four-cylinder car engine which gets 30 miles per gallon. At sixty miles per hour, the engine burns two gallons (about 12 pounds) of gasoline per hour.

If the engine is running at 2,400 rpm, then 1,200 sparks occur per minute in each cylinder (one spark every two revolutions in a four-cycle engine). In the hour in question, 72,000 sparks occurred in the cylinder (1,200 x 60). For four cylinders, 288,000 sparks occurred total.

Those 288,000 sparks, with Kumagai's electric field, processed two gallons, or about 12 pounds, of gasoline. To repeat: 288,000 sparks processed 12 pounds of fuel, in one hour.

In a gas turbine engine, the parameter of interest is Specific Fuel Consumption, SFC, which is the number of pounds of fuel required to produce one pound of thrust (or shaft horsepower) for one hour.

Some Boeing 747 aircraft use General Electric CF6 engines, of roughly 50,000 pounds thrust each. For simplicity, 72,000 pounds of thrust will be assumed, for reasons which will become immediately clear.

An SFC of 0.5 will be assumed for simplicity. So each engine burns 36,000 pounds of fuel per hour (explaining the assumption of

72,000 pounds thrust: double 36,000).

This gas turbine engine consumes about 3,000 times the fuel per hour as Kumagai's engine: 36,000 pounds versus 12 pounds.

If the CF6 contains a single igniter, then that igniter must process 36,000 pounds of fuel per hour, which is 3,000 times more than each spark plug does in Kumagai. If two igniters are present, then each must process half as much, and so on.

Therefore, since the amount of fuel consumed by a gas turbine engine is so much greater (3,000 times greater in this example) than the amount consumed by Kumagai's engine, it is highly doubtful that Kumagai's spark plugs could have any effect. The amount of fuel is simply too large. Kumagai's electric field would simply have no effect on the huge amount of fuel consumed by a gas turbine engine.

This can be viewed another way. The combustor in a gas turbine engine produces a flame much like a giant blow torch. The engine discussed above burns 36,000 pounds of fuel per hour, or **TEN POUNDS** per second.

Applicants respectfully submit that it is ridiculous to expect that Kumagai's tiny spark plug could have **any effect whatsoever** on this blow-torch-like flame.

Four. The PTO is comparing apples with oranges, part 2.

When a gas turbine engine is started, fuel flow is reduced to

the idle level. This also applies when the engine is re-started in flight.

Idle fuel flow for the engine assumed above is roughly 600 pounds per hour, or ten pounds per minute, or one pound every six seconds.

In theory, under the correct conditions, Kumagai's automotive spark plug could ignite this fuel.

However, in practice, an automotive spark plug would not be used. It cannot reliably ignite such a large amount of kerosene, because of the small amount of heat the spark plug produces, compared with the amount of kerosene present.

The undersigned attorney confirmed this lack of reliability with George Coffinberry, a retired engineer with General Electric Aircraft Engines, on November 28, 2005. Mr. Coffinberry holds numerous patents on gas turbine engines and, until a few years ago, held more patents than anyone else at GE aircraft engines.

Applicants offer to supply an affidavit on this point, if the Examiner so requests. The affidavit will state that, in practice, an automotive spark plug would not be used to ignite a gas turbine engine, because the amount of heat produced is too small, from the perspective of reliability.

Five. The Office Action asserts that Rothenbuhler states that "wear of the insulation occurs." That is not correct. He states

that "the annular ground electrode edge 22 . . . is subject to spark erosion." (Column 2, lines 61 - 63.)

He states that the **electrode** erodes, not the insulator.

Six. The Office Action asserts that Kumagai's attraction electrode of his Figure 4 can generate a plasma, when the insulation erodes away. However, Kumagai does not discuss this mode of operation.

Further, as explained above, Kumagai states that, in the exposed electrode of his Figure 1, a "glow discharge" occurs. (Column 1, line 22.) Applicants point out that a "glow discharge" does not necessarily create a high temperature. For example, an ordinary fluorescent light creates a glow discharge, yet it is cool.

Seven. The Office Action proposes an experimentation program in which Kumagai is modified, so that the insulation in his Figure 11 is made sufficiently thin. This thin insulation then wears away rapidly, and electrode 57 becomes exposed. Electrode 57 then supposedly generates a spark.

However, several problems exist in this experiment. One problem is that this proposal modifies Kumagai. MPEP § 2143.01 prohibits this:

> THE PROPOSED MODIFICATION CANNOT RENDER THE PRIOR ART UNSATISFACTORY FOR ITS INTENDED PURPOSE.
>
> . . .
>
> THE PROPOSED MODIFICATION CANNOT CHANGE THE PRINCIPLE OF OPERATION OF A REFERENCE.

Further, Kumagai is modified in a manner that makes him inoperative. Exposing electrode 57 renders his spark plug unfit for its intended purpose.

Further still, no teaching for this modification is found in the prior art. Plainly, the motivation is to attain a device upon which Applicants' claim read.

Since no motivation is found in the prior art, and since the modification renders Kumagai unfit for its intended purpose, it is clear that the motivation is found in Applicants' own disclosure.

MPEP § 706.02(j) states:

> Contents of a 35 U.S.C. 103 Rejection
>
> . . .
>
> To establish a prima facie case of obviousness, three basic criteria must be met.
>
> First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings.
>
> . . .
>
> Finally, the prior art reference (or references when combined) must teach or

> suggest all the claim limitations.
>
> The teaching or suggestion to make the claimed combination . . . **must . . . be found in the prior art** and not based on applicant's disclosure.

Eight. The rejections fail to comply with MPEP § 706.02(j), which states:

> Contents of a 35 U.S.C. 103 Rejection
>
> 35 U.S.C. 103 authorizes a rejection where, to meet the claim, it is necessary to modify a single reference or to combine it with one or more other references. After indicating that the rejection is under 35 U.S.C. 103, the examiner should set forth in the Office action:
>
> (A) the relevant teachings of the prior art relied upon, preferably with reference to the relevant column or page number(s) and line number(s) where appropriate,
>
> (B) the difference or differences in the claim over the applied reference(s),
>
> (C) the proposed modification of the applied reference(s) necessary to arrive at the claimed subject matter, and
>
> (D) an explanation why one of ordinary skill in the art at the time the invention was made would have been motivated to make the proposed modification.
>
> To establish a prima facie case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine

> reference teachings.
>
> Second, there must be a reasonable expectation of success.
>
> Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.
>
> The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art and not based on applicant's disclosure.

Nine. The Office Action invokes the Doctrine of Inherency, by asserting that Kumagai's electrode 57 will inherently become exposed due to erosion, and then generate spark.

MPEP § 2112 states:

> EXAMINER MUST PROVIDE RATIONALE OR EVIDENCE TENDING TO SHOW INHERENCY.
>
> In relying upon the theory of inherency, the examiner must provide a **basis in fact and/or technical reasoning** to reasonably support the determination that the allegedly inherent characteristic necessarily flows from the teaching of the applied prior art.

The PTO has not shown the required "basis in fact and/or technical reasoning."

Ten. The Office Action asserts that Kumagai's attraction electrode will produce spark when exposed. However, (1) that is doubtful and, (2) even if spark occurs, the spark will occur at the wrong time, causing faulty running of the engine.

These facts were explained in the Major Points, given above.

No Actual Teaching Given

The Office Action fails to give a teaching for combining and modifying the references. The Office Action's approach is essentially to assert that:

-- Eventually, the insulation in Kumagai will inherently erode,

-- The now-exposed electrode 57 in Kumagai will generate spark, and

-- A modification of the thickness of Kumagai's insulation will cause this erosion to occur at an early time.

However, the modification of the thickness renders Kumagai inoperative. That is not allowed in a teaching.

PTO Has Not Shown Why References Want Two Electrodes

After the PTO modifies Kumagai's Figure 3 or 11, according to the PTO's reasoning, Kumagai now has two sparking electrodes.

But the PTO has not explained **WHY** Kumagai would want two such electrodes.

Applicants submit that an explanation is needed, since a motivation is required for the modification.

An explanation is further needed because, as explained herein,

(1) the battery BATT of Kumagai's Figure 11 does not produce spark (a step-up coil is required) and (2) the spark of Kumagai's electrode 30 in his Figure 3 is not needed and also occurs at the wrong time.

Erosion Used in PTO's Reasoning is Not Shown in Prior Art

Applicants point out that Rothenbuhler states that erosion occurs in his **metallic electrode**. (Column 2, lines 63 - 64.)

The PTO relies on Applicants' statement in the Summary of the Invention that "Normal operation of an igniter in a gas turbine engine causes erosion of an insulator inside the igniter."

But the supposed erosion upon which the PTO relies to reject the claims is in the insulator of Kumagai. That insulator is in a spark plug in an automobile.

The PTO has not shown in the prior art that erosion occurs in such spark plugs.

And Applicants' statement is not applicable to such spark plugs, because they operate in a completely different environment, and in a different way, compared with an igniter in a gas turbine engine. As explained above, it is the spark brushing against the insulator in a gas turbine igniter which causes erosion. Such brushing is not present in an automotive spark plug.

No Evidence Given Supporting Rationale for Combining References

The Office Action, page 6, bottom, asserts that the references, which it combines and modifies, facilitates lean burning. But that is a naked conclusion, unsupported by evidence. Evidence is required.

Further, the Kumagai reference is cited to show the supposed lean burning. However, the PTO **modifies** that reference. The modification **eliminates the lean-burning feature**.

That is, the modification exposes electrode 57 in Kumagai's Figure 11. Kumagai states that this exposure causes a "glow discharge," which fails to draw the fuel particles to the spark gap. (Column 1, lines 18 - 26.)

Therefore, the PTO sets forth the goal of lean burning, but its modification of the references fails to attain lean burning. Thus, that goal (lean burning) cannot be used as a teaching, since the PTO modifies the references to eliminate the supposed lean burning.

No motivation for combining and modifying the references has been given, as required by section 103.

CLAIMS 4, 13, and 16

These claims are considered patentable, based on their parent claims.

In addition, even if the references are combined, the claims are not attained.

The claims state that current is detected in the electrode which becomes exposed. No such electrode is shown in Owens.

Thus, even if Owens is combined with the references, Owens would be used to detect current in the electrodes which initially produce spark, not the electrode which is later exposed.

Also, no teaching has been given for combining the references. The goal stated is to "monitor the status of the second/embedded electrode." However, that is impossible.

So long as the second electrode remains embedded, it produces no spark, and Owens detects no current. Thus, no "{monitoring" of that electrode occurs.

Since the goal cannot be attained, it cannot act as a teaching for combining the references.

From another point of view, the PTO has shown no expectation of success, as required by MPEP § 706.02(j), cited elsewhere herein.

Claim 17

Claim 17 is considered patentable, based on its parent.

Also, even if the references are combined, all claim elements have not been shown. Under claim 17 and its parent, the **embedded** electrode is cylindrical. That has not been shown in the references.

If the cylindrical electrodes of the references are embedded,

then they become inoperative. This is contrary to MPEP § 2143.01, section 5, which states:

> The proposed modification cannot render the prior art unsatisfactory for its intended purpose.

Claim 23

Claim 23 was rejected as obvious, based on Eaton and Rothenbuhler.

Point 1

The rationale for modifying the references is not the type allowed by the rules on obviousness.

The rationale is that it is obvious to use a marker in a gas turbine engine to facilitate maintenance.

That's like saying that the first airplane is not patentable because people have always wanted to fly.

The mere fact that a combination of references produces a desirable result is not a basis for rejection.

Point 2

As explained above, no marker in Rothenbuhler "becomes" visible. It is always visible. It merely becomes larger.

Point 3

Even if the references are combined, the claim is not attained.

The supposed "marker" in Rothenbuhler is a **ring**, V-shaped in cross section.

Eaton's nickel sheath 18 in his Figure 4 has worn away, after several thousand miles of operation. (Column 3, lines 37, 38.)

If Rothenbuhler's ring is cut into the end of Eaton's nickel sheath 18, then, when the erosion of Eaton's Figure 4 occurs, that ring **disappears**.

No "marker" is present, as claimed.

Point 4

No expectation of success has been shown, showing a structure that actually works.

MPEP § 706.02(j) states:

> Contents of a 35 U.S.C. 103 Rejection
>
> . . .
>
> To establish a prima facie case of obviousness, three basic criteria must be met.
>
> . . .
>
> Second, there must be a reasonable expectation of success.
>
> . . .

> The . . . reasonable expectation of success must both be found in the prior art and not based on applicant's disclosure.

That is, the Office Action has not actually shown a structure which the combined references provide, which operates as claimed.

Point 5

The court stated in In re Payne, 606 F. 2d 303, 203 USPQ 245 (CCPA 1979):

> References relied upon to support a rejection under 35 USC 103 must provide an **enabling disclosure**, ie, they must place the claimed invention in the possession of the public
> . . .
> An invention is not "possessed" absent some known or obvious way to make it.

The PTO has not shown how the references are assembled to provide claim 23.

CONCLUSION

Applicants express thanks for the careful consideration given to this case.

Applicants request that the rejection of all claims be reconsidered and withdrawn.

Respectfully submitted,

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December 16, 2005

ATTACHED: APPENDIX A

Spark Plug Tech Info

Always open spark-plug sales

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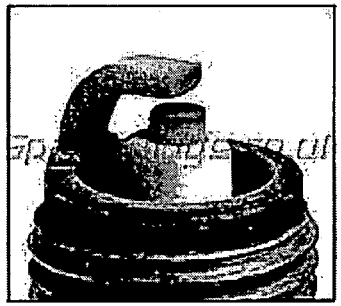
Technical Information

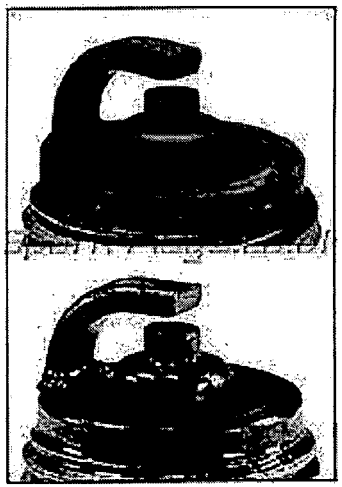
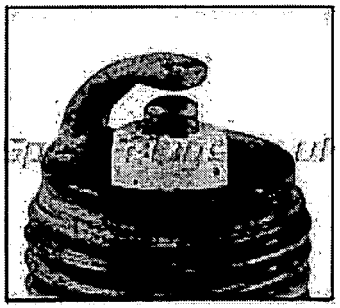
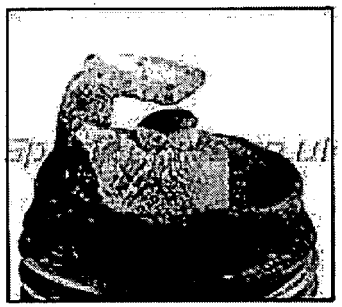
Technical sections

Fault Diagnosis

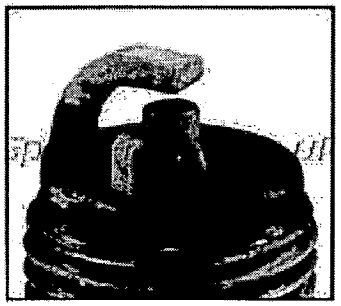
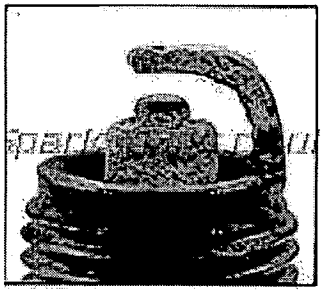
This section identifies some common faults associated with spark plug wear, incorrect applications and general problems with engine running conditions. The condition of the firing end of a spark plug is a good indicator of the general health of an engine.

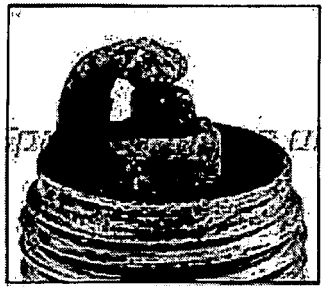
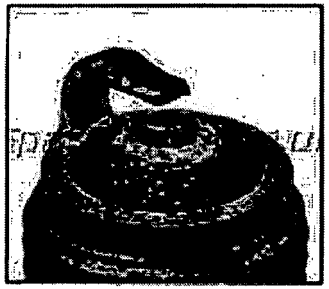
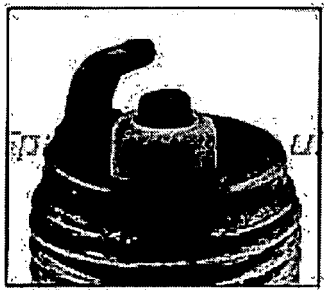
	Appearance	Possible cause/resolution
	**Normal** Light brown, tan or grey firing end.	A good indicator that the plug is functioning correctly and general engine conditions are good.
		Can be caused by many different conditions. Carbon deposits build up

APPENDIX A

	**Dry and wet fouling** Fouling, either dry (top - matt black, sooty) or wet (bottom - gloss black, sticky),	when the plug fails to fire correctly and burn them off. Air/fuel mixture too rich, choke stuck on, electrical problem, extended periods of low speed driving, plug heat range too cold. All should be investigated
	**Overheating** When overheating occurs, deposits which have accumulated on the insulator tip may melt and give the tip a glazed appearance	Possible causes are overadvanced ignition timing, air/fuel mixture too lean, water or oil level too low, plugs not fitted (tightened) correctly, plug heat range too hot.
	**Deposits** Insualtor nose and electrodes encrusted with a build of deposits - usually off white in colour.	This is often caused by oil leakage through the piston rings or valve seals. Could be due to the wrong viscosity of oil being used.
	Lead fouling Lead deposits on the	Lead content of petrol used

APPENDIX A

	insulator nose. These are usually a yellowish brown in colour.	is too high. Try petrol with a lower lead content.
	**Breakage** Physical damage to the insulator nose.	Usually caused by abnormal thermal expansion in the combustion chamber. Maybe thermal heating or cooling shock. Causes as for overheating above.
	**Normal life** Growth of the plug gap during a plug's working life is normal. However, the increased gap will mean the spark is less efficient and hence fuel is wasted and strain is put on the ignition system.	Plugs are at the end of servicable life. Replace plugs as a set.
	**Abnormal erosion** This is accelerated growth of the gap	due to the effects of corrosion, oxidation and reaction with the lead in petrol.

	**Melting** The electrode surface will probably appear lustrous and uneven.	Due to excessively high temperatures in the combustion chamber. Causes as for overheating above.
	**Erosion, Corrosion, Oxidisation** The surfaces of the electrodes are rough, in extreme circumstances the electrode material will have oxidised to the point of turning green	Possibly due to age, vehicle standing for a long time without use.
	**Lead Erosion** The ground electrode will appear worn away, the central electrode will appear chipped and the insulator nose will take on a yellowish brown.	This is due to chemical reaction between the nickel alloy electrodes and the lead compounds in petrol.

APPENDIX A